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<u>AUSTRALIA</u>

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COMPLETE SPECIFICATION

STANDARD PATENT

Applicants:

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Invention Title:

A COMPOSITE BEAM

The following statement is a full description of this invention, including the best method of performing it known to me/us:

sheeting having a plurality of pans separated by ribs, the profiled sheeting being positioned in relation to the beam so that the ribs are parallel to the longitudinal axis of the beam or the ribs and the longitudinal axis of the beam describe an acute angle of less than or equal to 15°;

(ii) concrete cast on the sheeting; and

(iii) reinforcement embedded in the concrete; and

(c) a plurality of shear connectors, typically in the form of headed studs, embedded in the concrete and extending through the sheeting and welded to the beam thereby to connect the composite slab to the beam.

The present invention is concerned with reinforcing the type of composite beams described in the preceding paragraph so that the composite beams have sufficient shear capacity to prevent premature longitudinal shear failure of the composite beams.

An object of the present invention is to provide a composite beam with improved resistance to longitudinal shear failure.

According to the present invention there is provided a composite beam which includes:

(a) a beam;

(b) a composite slab positioned on and supported

by the beam, the composite slab including:

(i) profiled sheeting having a plurality of pans separated by ribs, the profiled sheeting being positioned in relation to the beam so that the ribs are parallel to the longitudinal axis of the beam or the ribs and the longitudinal axis of the beam describe an acute angle of less than or equal to 15°;

(ii) concrete cast on the profiled sheeting;

(c) a plurality of shear connectors which connect the composite slab to the beam; and

(d) a reinforcing component embedded in the concrete slab, the reinforcing component having a reinforcing element that extends through an imaginary surface that passes through the tops of the ribs of the profiled sheeting and the tops of the shear connectors to prevent premature longitudinal shear failure of the composite beam at that surface.

The above-described imaginary surface is hereinafter referred to as "the longitudinal shear failure surface".

In this context, longitudinal shear failure could be the result of longitudinal shear stresses developing over the longitudinal shear failure surface due to sagging (ie positive) and/or hogging (ie negative) bending of the composite beam at one or more locations along the length of

the beam. Tensile stresses may also develop over the longitudinal shear failure surface due to other factors, such as due to Vierendeel action at large penetrations in the steel beam web, or at locations of hanging loads such as where a secondary beam connects to a primary beam, which can promote cracking along the failure surface.

The applicant has found that the reinforcing component described in sub-paragraph (d) above improves dramatically the transfer of horizontal force between the composite slab and the beam of the composite beam. This improved transfer of longitudinal shear force can be measured by reference to the improvement in shear strength and ductility (ie slip capacity) of the shear connection of the composite beam.

As a consequence, the present invention makes it possible to avoid premature longitudinal shear failure of the structural composite beam at loads below the load at which the shear connectors have achieved full potential strength.

In addition, as a consequence, the present invention makes it possible to use significantly fewer shear connectors than would otherwise be required.

It is preferred that the beam be a steel beam.

It is preferred that the profiled sheeting be profiled steel sheeting.

It is preferred that the beam be supported at each end.

The beam may be supported also at one or more locations along the length of the beam.

The beam may be an internal beam or a perimeter beam.

It is preferred that the composite slab further includes reinforcement such as welded wire mesh embedded in the concrete of the composite slab.

It is preferred that the shear connectors be headed studs. The shear connectors may be of any other suitable form such as a structural bolts or channels or shot-fired connectors.

In one arrangement it is preferred that the reinforcing component includes welded wire mesh that extends along the length of the beam and has a series of folds with:

(a) peaks located above the tops of the ribs and the tops of the shear connectors; and

(b) troughs contacting the profiled sheeting.

With such an arrangement, the reinforcing element includes the sections of the wires of the welded wire mesh that extend between the peaks and the troughs and thereby extend through the longitudinal shear failure surface.

In an alternative (but not the only alternative) arrangement, it is preferred that the reinforcing component be a lattice girder that extends along the length of the beam and at least partially encloses the shear connectors, the lattice girder including longitudinal wires and cross-wires interconnecting the longitudinal wires, with at least one longitudinal wire being above the tops of the ribs and the shear connectors and at least one longitudinal wire contacting the profiled sheeting.

With such an arrangement, the reinforcing element includes the cross-wires of the cage that extend through the longitudinal shear failure surface.

The present invention is described further by way of example with reference to the accompanying drawings of which:

Figure 1 is a perspective view which illustrates, in simplified form, an embodiment of a composite beam (without a layer of concrete that forms part of the beam) in accordance with the present invention;

Figure 2 is an elevation of the composite beam shown in Figure 1 (with the layer of concrete illustrated in the Figure) in the direction of the arrow A in Figure 1;

Figure 3 is a perspective view of the reinforcing component of the embodiment of the composite beam in accordance with the present invention that is shown in Figures 1 and 2;

Figure 4 is a side elevation of another embodiment of a composite beam in accordance with the present invention;

Figure 5 is a perspective view of the reinforcing component of the embodiment of the composite beam in accordance with the present invention that is shown in Figure 4;

Figure 6 is an elevation, in the same direction as the arrow A in Figure 1, of another embodiment of a composite beam in accordance with the present invention; and

Figure 7 is a perspective view of a reinforcing

component of another embodiment of a composite beam in accordance with the present invention.

The preferred embodiment of the composite beam 3 in accordance with the present invention that is shown in Figures 1 to 3 is in a simplified form to illustrate the composite beam 3 more clearly.

With reference to Figures 1 and 2, the composite beam 3 includes:

(a) a horizontally extending hot-rolled or fabricated steel beam 5 which is supported at each end and at least one location along the length of the beam so that the beam extends across multiple spans between the beam supports;

(b) a composite slab including:

(i) profiled steel sheeting 7 in contact with a top flange 9 of the steel beam 5, the sheeting 7 including a plurality of parallel steel ribs 11 separated by pans 13 and positioned so that the ribs 11 extend in a direction that is parallel to the longitudinal axis of the beam 5; and

(ii) a layer 29 of concrete cast on the sheeting 7 and having an upper surface 31 (shown in Figure 2 only);

(c) a plurality of pairs of shear connectors 15 in the form of headed studs that extend through the sheeting 7 and are welded to the top flange 9 of the beam 5 at spaced

intervals along the length of the beam 5; and

(d) a reinforcing component generally identified by the numeral 19 embedded in the concrete slab for preventing premature longitudinal shear failure of the composite beam 3.

The beam 5 and the composite slab may be of any suitable dimensions and construction. Typically, the composite slab has a thickness of at least 120mm.

In addition, whilst the sheeting 7 shown in Figures 1 and 2 has a trapezoidal profile, the sheeting 7 may be dovetail or of any other suitable shape.

The reinforcing component 19 shown in Figures 1 to 3 is formed from welded wire mesh having two longitudinal wires 41 and a number of cross-wires 47 interconnecting the longitudinal wires 41.

The reinforcing component 19 is formed by bending the longitudinal wires 41 of the welded wire mesh to form, as can best be seen in Figure 3, a series of folds having peaks 43 and troughs 45.

The reinforcing component 19 is formed with regard to the height of the ribs 11 and the height of the shear connectors 15 so that, when the reinforcing component 19 is positioned with the longitudinal wires 41 parallel to the ribs 11:

(a) the peaks 43 of the folds are above the tops of the shear connectors 15 and the tops of the ribs 11; and

(b) the troughs 45 of the folds contact the pans

13 of the sheeting 7.

With the above arrangement, the cross-wires 47 of the welded wire mesh extend transversely to the ribs 11 of the sheeting 7. In addition to holding together the longitudinal wires 41, the cross-wires 47 contribute to anchoring the reinforcing component 19 in the concrete of the composite slab.

When a structural composite beam 3 of the basic type shown in the Figures 1 to 3 is loaded, longitudinal slip is induced between the composite slab and the steel beam 5 which is resisted by the shear connection between these components.

In a conventional structural composite beam (without the reinforcing component 19) the shear connection includes:

(a) the shear connectors 15;

(b) concrete cast in a slab; and

(c) conventional horizontal reinforcement in the vicinity of the shear connectors 15.

However, in accordance with the present invention, the shear connection also includes the reinforcing component 19.

The reinforcing component 19 is designed to specifically prevent premature longitudinal shear failure and, in particular, premature longitudinal shear failure caused by a mechanism of splitting of the composite slab at the longitudinal shear failure surface generally identified by the dotted line 37 in Figure 2, as well as by other mechanisms.

As is described previously, and as shown in Figure 2, the longitudinal shear failure surface 37 extends through the tops of the ribs 11 and the tops of the shear connectors 15.

Specifically, the reinforcing component 19 includes the sections of the longitudinal wires 41 that are between the peaks 43 and the troughs 45 and extend through the longitudinal shear failure surface 37. These sections form reinforcing elements of the reinforcing component 19 that resist premature longitudinal shear failure.

In general terms, the reinforcing component 19 is designed to significantly improve the transfer of horizontal forces between the composite slab and the steel beam 5.

Figures 4 and 5 illustrate another embodiment of a composite beam 3 in accordance with the present invention. The composite beam 3 has the same basic components as the composite beam 3 shown in Figures 1 to 3 and the same reference numerals are used in the Figures to describe the same components.

The only difference between the embodiments is the form of the reinforcing component 19.

Specifically, the reinforcing component 19 shown in Figures 4 and 5 includes the structure of the reinforcing component 19 shown in Figures 1 to 3 and additional reinforcement in the form of transverse bars 25.

The reinforcing component 19 is formed so that, when the reinforcing component is in the composite beam 3, the transverse bars 25 are below the level of the tops of the shear connectors (as shown in Figure 4). The transverse bars 25 are provided to contribute to preventing

longitudinal splitting along the line of the shear connectors 15.

Figure 6 illustrates another embodiment of a composite beam 3 in accordance with the present invention. The composite beam 3 has the same basic components as the composite beams 3 shown in Figures 1 to 5 and the same reference numerals are used in the Figures to describe the same components.

The only difference between the embodiments is the form of the reinforcing component 19.

Specifically, the reinforcing component 19 shown in Figure 6 is in the form of a lattice girder that has a generally triangular transverse cross-section and includes upper and lower longitudinal wires 51 and a series of pairs of cross-wires 53 that are welded at opposite ends to the longitudinal cross-wires 51 at spaced intervals along the length of the longitudinal wires 51.

The lattice girder is positioned in the composite beam 3 so that the lattice girder at least partially encloses the pairs of shear connectors 15 along the length of the beam 5. More particularly, the lattice girder is formed so that, in use:

(a) the upper longitudinal wire 51 is above the tops of the shear connectors 15 and the ribs 11; and

(b) the lower longitudinal wires 51 are close to the pan 13 and the spacing of the wires is greater than the width of the pairs of connectors 15.

With the above described arrangement there are

sections of the cross-wires 53 that extend through the longitudinal shear failure surface 37 and form reinforcing elements that resist premature longitudinal shear failure. In this context, it is noted that the upper and lower longitudinal wires 51 provide anchorage for the cross-wires 53 across the longitudinal shear failure surface 37.

Figure 7 illustrates another, although not the only other possible, embodiment of a lattice girder that is suitable for use as a reinforcing component 19. The lattice girder has a generally rectangular transverse section and includes upper and lower longitudinal wires 61 and a series of cross-wires 63 that are welded at opposite ends to the longitudinal wires 61 at spaced intervals along the length of the longitudinal wires 61.

Many modifications may be made to the preferred embodiments of the present invention as described above without departing from the spirit and scope of the present invention.

By way of example, whilst the preferred embodiments of the composite beam include pairs of shear connectors 15 along the length of the beams 5, the present invention is not limited to this arrangement and extends to any suitable arrangements such as arrangements in which there are single rather than pairs of shear connectors.

Furthermore, whilst the preferred embodiments are arrangements in which the ribs 11 are parallel to the longitudinal axis of the beam 5, the present invention is not so limited and extends to arrangements in which the ribs 11 and the longitudinal axis describe an acute angle of 15° or less.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A composite beam which includes:

(a) a beam;

(b) a composite slab positioned on and supported by the beam, the composite slab including:

(i) profiled sheeting having a plurality of pans separated by ribs, the profiled sheeting being positioned in relation to the beam so that the ribs are parallel to the longitudinal axis of the beam or the ribs and the longitudinal axis of the beam describe an acute angle of less than or equal to 15°;

(ii) concrete cast on the profiled sheeting;

(c) a plurality of shear connectors which connect the composite slab to the beam; and

(d) a reinforcing component embedded in the concrete slab, the reinforcing component having a reinforcing element that extends through an imaginary surface that passes through the tops of the ribs of the profiled sheeting and the tops of the shear connectors to prevent premature longitudinal shear failure of the composite beam at that surface.

2. The composite beam defined in claim 1 wherein the

reinforcing component includes welded wire mesh that extends along the length of the beam and has a series of folds with:

(a) peaks located above the tops of the ribs and the tops of the shear connectors; and

(b) troughs contacting the profiled sheeting;

whereby the reinforcing element includes sections of the wires of the welded wire mesh that extend between the peaks and the troughs and thereby extend through the longitudinal shear failure surface.

3. The composite beam defined in claim 2 wherein the welded wire mesh includes at least two longitudinal wires that have the above-described folded form and cross-wires that interconnect the longitudinal wires.

4. The composite beam defined in claim 3 wherein the cross-wires are located at the peaks and troughs of the reinforcing component.

5. The composite beam defined in claim 3 or claim 4 further includes transverse bars that are connected to the longitudinal wires and positioned below the level of the tops of the shear connectors to provide additional reinforcement.

6. The composite beam defined in claim 1 wherein the reinforcing component includes a lattice girder that extends along the length of the beam and at least partially encloses the shear connectors, the lattice girder includes longitudinal wires and cross-wires interconnecting the longitudinal wires, with at least one longitudinal wire being above the tops of the ribs and the shear connectors and at least one longitudinal wire contacting the profiled

sheeting, and the reinforcing element includes cross-wires extending through the longitudinal shear failure surface.

7. The composite beam defined in any one of the preceding claims wherein the beam is a steel beam.

8. The composite beam defined in any one of the preceding claims wherein the profiled sheeting is profiled steel sheeting.

9. The composite beam defined in any one of the preceding claims wherein the composite slab further includes reinforcement such as welded wire mesh embedded in the concrete of the composite slab.

10. The composite beam defined in any one of the preceding claims wherein the shear connectors are headed studs.

11. A composite beam substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 11th day of September 2001
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<u>UNIVERSITY OF WESTERN SYDNEY</u>
By their Patent Attorneys
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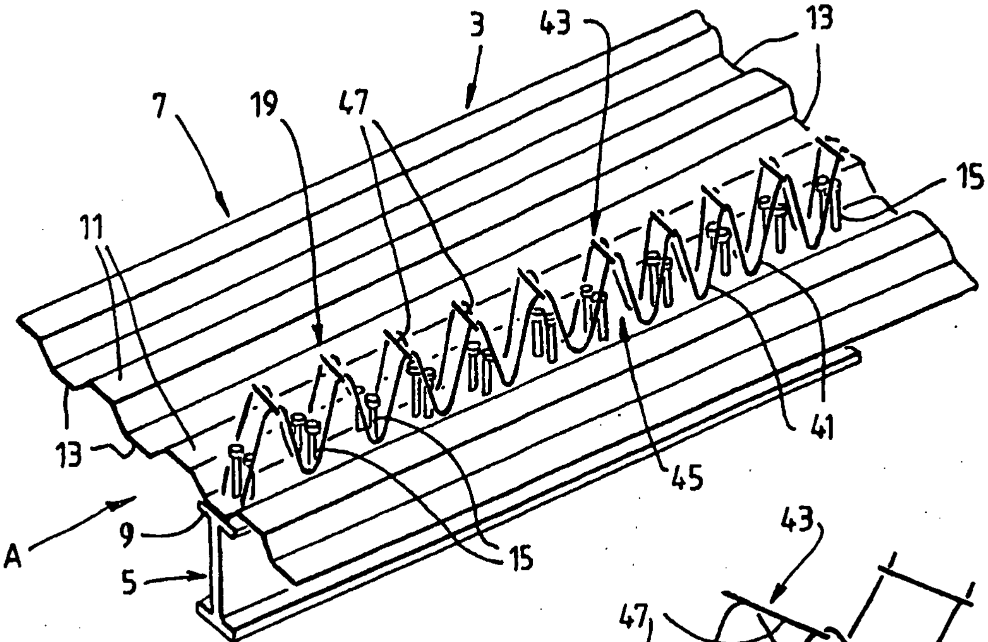

FIG. 1.

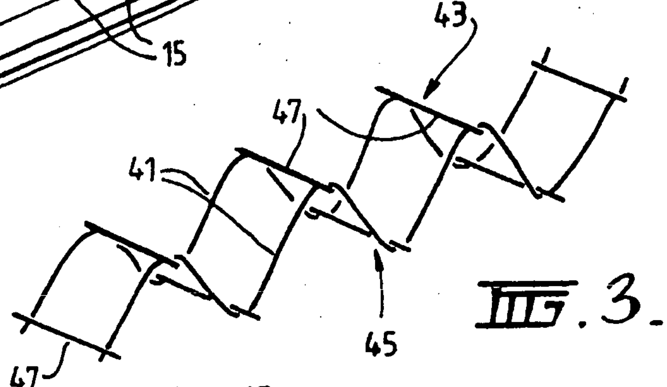

FIG. 3.

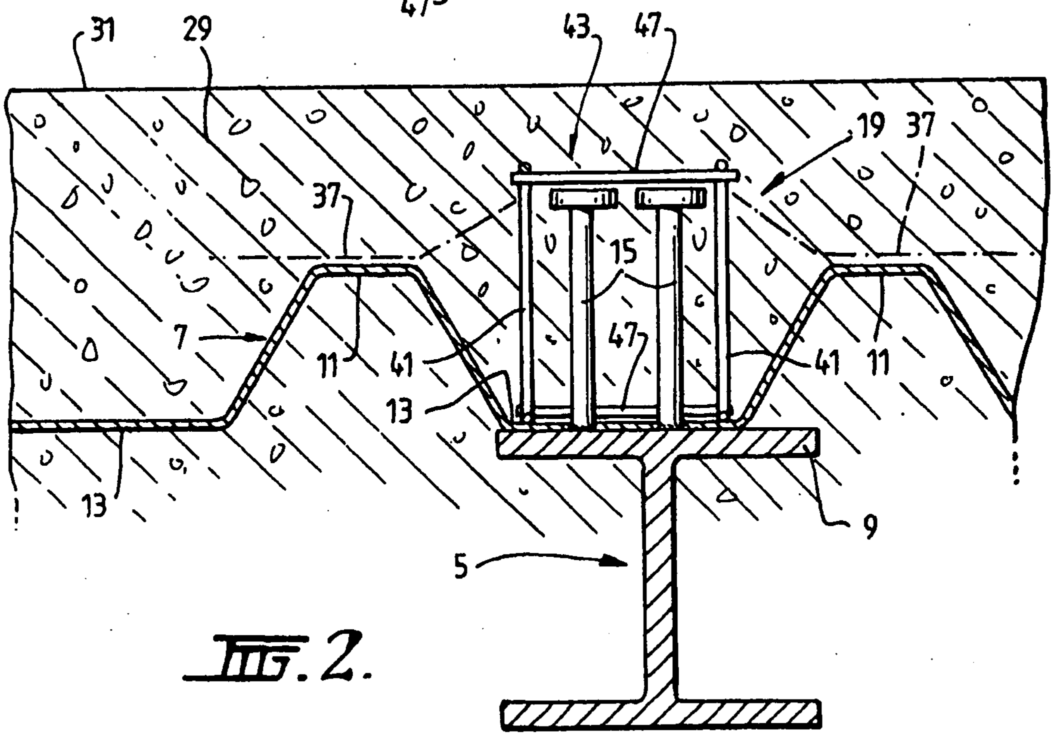

FIG. 2.

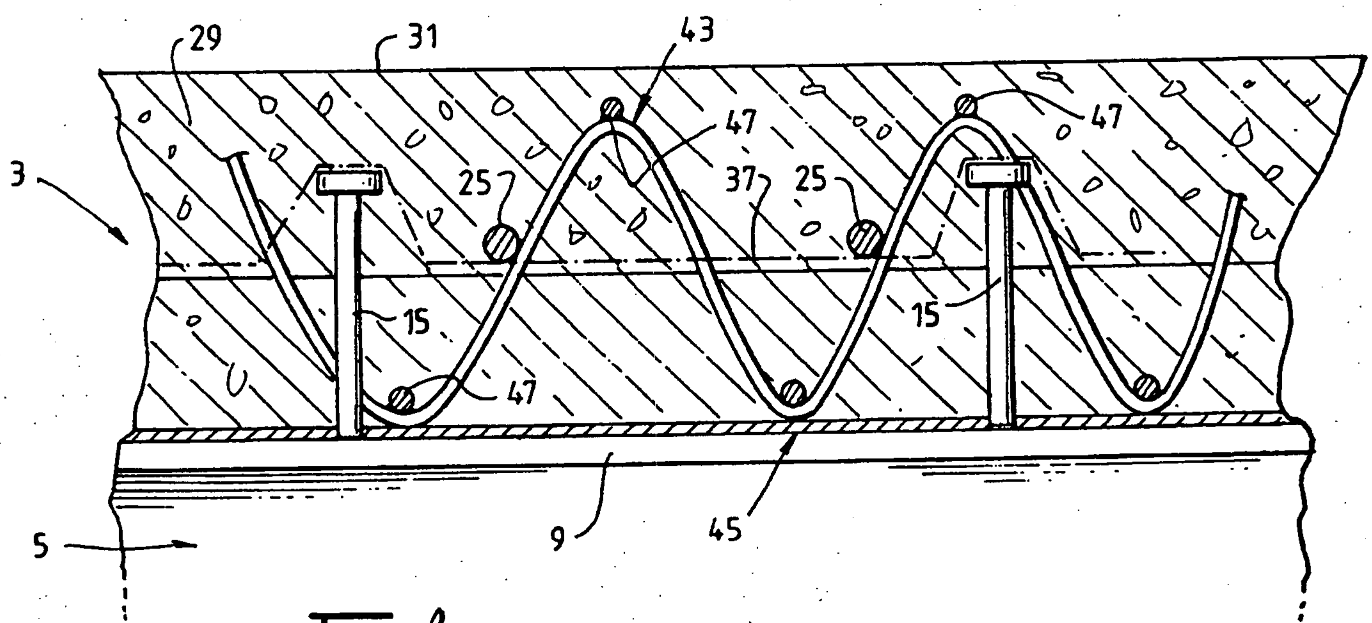

FIG. 4.

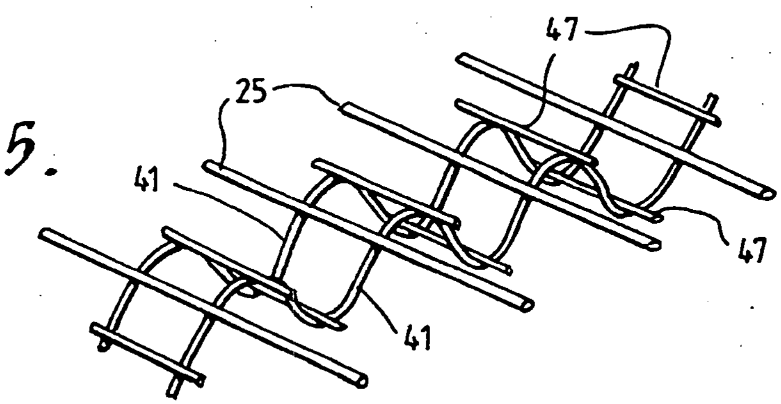

FIG. 5.

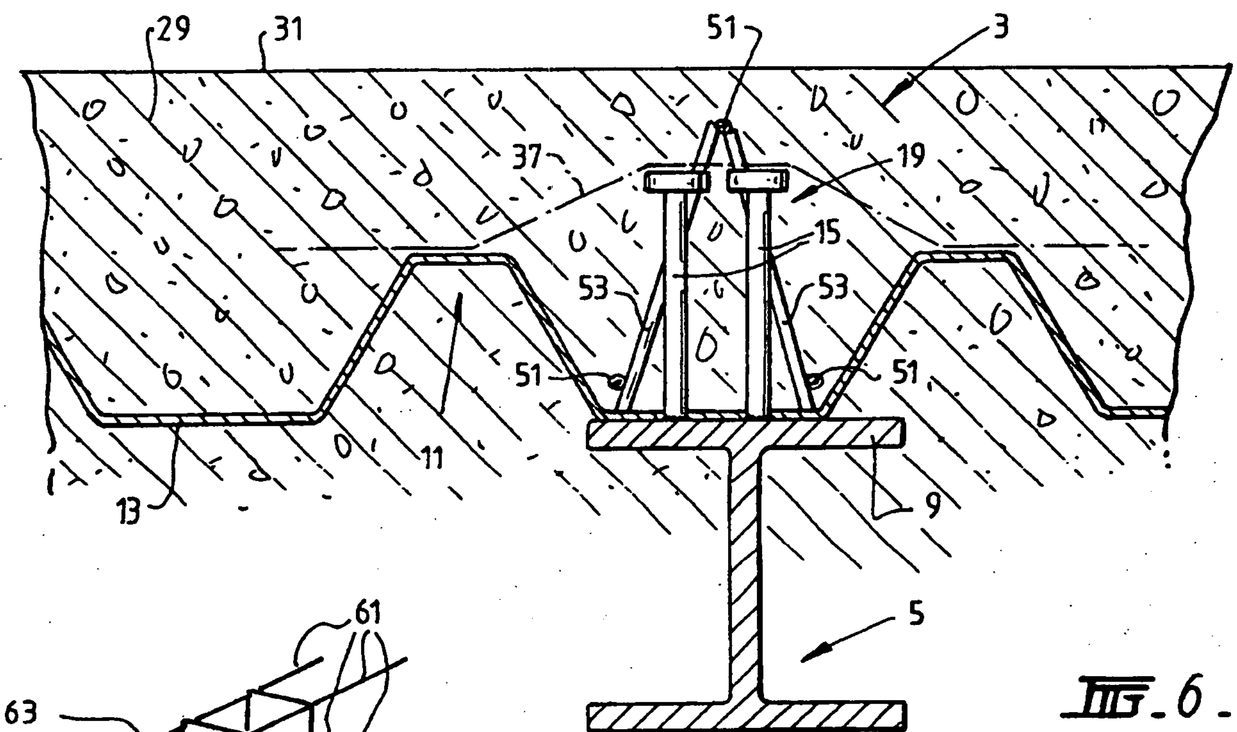

FIG. 6.

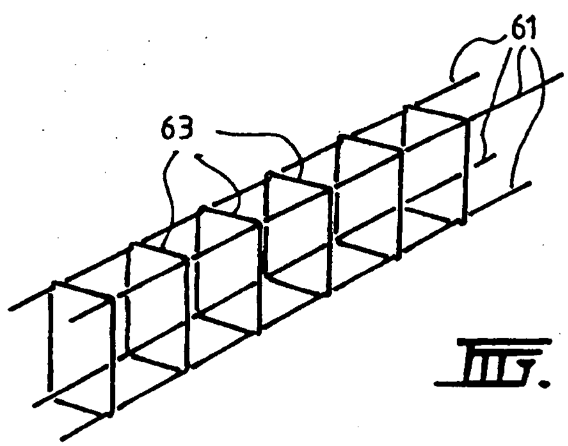

FIG. 7.

ABSTRACT

A composite beam is disclosed. The composite beam includes a beam (5) and a composite slab positioned on and supported by the beam. The composite slab includes profiled sheeting (7) having a plurality of pans (11) separated by ribs (13). The profiled sheeting is positioned in relation to the beam so that the ribs are parallel to the longitudinal axis of the beam or the ribs and the longitudinal axis of the beam describe an acute angle of less than or equal to 15°. The composite slab also includes a layer of concrete (29) cast on the profiled sheeting. The composite beam also includes a plurality of shear connectors (15) that connect the composite slab to the beam and a reinforcing component (19) embedded in the concrete slab. The reinforcing component has reinforcing sections that extend through an imaginary surface that passes through the tops of the ribs of the profiled sheeting and the tops of the shear connectors to prevent premature longitudinal shear failure of the composite beam at that surface.